PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) SWITCH APPARATUS

(71) We, TEKTRONIX, INC., a corporation organized under the laws of the State of Oregon, United States of America, of 14150 S.W. Karl Braun Drive, Beaverton, Oregon 97005, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed; to be particularly described in and by the following statement:—

This invention relates generally to electrical switches and in particular to cam actuated switches in which the movable and fixed contacts of the switch are mounted on a printed circuit board. The term "printed circuit board" as used herein includes circuit boards made by photoresist masking and etching or other techniques in which the electrical conductors of a circuit are formed as conductive strips on a surface of a support plate of insulating material which may or may not have electrical circuit components, such as resistors, capacitors, and transistors, mounted thereon.

According to the present invention, there is provided switch apparatus, comprising: printed circuit board means including a support member of insulating material having a plurality of spaced, insulated conductive regions thereon forming portions of an electrical circuit; switch means for changing the connections of said circuit portions, including a plurality of pairs of switch contacts connected to at least some of said conductive regions with the movable switch contacts of said switch means being fixedly attached to said support member of said circuit board means; and cam actuator means including a cam member having a plurality of separate cam portions thereon for selectively moving said movable contacts with said cam portions to open and close the pairs of switch contacts, said cam actuator means being mounted on the same side of the circuit board as the switch contacts to provide a unitary switch apparatus.

The switch apparatus of the present invention is especially useful for circuits in a cathode ray oscilloscope. By providing the movable and fixed switch contacts on the printed circuit board, such contacts may be mounted closer to the circuit elements being switched. This reduces lead inductance and series resistance, and also reduces the contact capacitance to ground and to adjacent elements, thereby enabling a higher frequency response for the circuit to which the switch is connected. In addition, the number of soldered connections for the switch is greatly reduced, since the fixed contacts may be formed as part of the printed circuit and the movable contacts are soldered directly to the printed circuit board without the use of conventional interconnecting wires. As a result of this reduction in the number of soldered connections, the present apparatus is quicker and less expensive to install, is easier to repair, and is of higher reliability.

Previously, some rotary switches have been made which employ a stator member in the form of a printed circuit board having fixed contacts provided thereon. However, these switches differ from the present switch in that their movable contacts are mounted on a separate rotor member. These prior rotary switches have a concentricity alignment problem which is avoided in the present switch, since in the prior switch the rotor and stator members must be mounted coaxial and concentric to enable the contacts to engage one another properly. Also, because the movable contacts slide across the surface of the printed circuit board, such rotary switches require greater torque and have a shorter lifetime than the switch of the present invention, in which only the cam elements engage the movable switch contacts briefly. As a result of the lower torque, the switch of the present invention may be made with a smaller knob, requiring less mounting space on the front panel of the oscilloscope.

In order that the invention may be clearly understood, embodiments thereof will now be described in more detail, by way of example

only, with reference to the accompanying drawings, of which:

Fig. 1 is a plan view showing one embodiment of the switch apparatus of the present invention employing a rotary drum cam actuator with parts broken away for clarity to show some of the switch contacts;

Fig. 2 is a horizontal section view taken along the line 2—2 of Fig. 1, showing the switch on an enlarged scale;

Fig. 3 is a vertical section view taken along the line 3—3 of Fig. 2;

Fig. 4 is a vertical section view taken along the line 4—4 of Fig. 2;

Fig. 5 is an enlarged view of a portion of Fig. 3, showing the camming operation of the movable contact;

Fig. 6 is an elevation view of another embodiment of the switch apparatus of the present invention in which a sliding cam actuator is employed, with parts broken away for clarity;

Fig. 7 is a vertical section view taken along the line 7—7 of Fig. 6 with parts broken away for clarity; and

Fig. 8 is a horizontal section view taken along the line 8—8 of Fig. 6.

As shown in Figs. 1 and 2, one embodiment of the cam actuated switch apparatus of the present invention includes a rotary drum cam actuator 10 and a plurality of pairs of movable switch contacts 12 and fixed switch contacts 14 mounted on a printed circuit board 16, so that the switch contact pairs are longitudinally spaced along the axis of such cam drum. The cam drum 10 is provided with a plurality of sets of raised cam elements 18 with each cam element projecting radially outward and extending in an arc a short distance about the circumference of such drum. The sets of cam elements 18 are longitudinally spaced from one another along the axis of the cam drum and positioned so that at least one set of such cam elements engages each of the movable contacts 12 when the drum is rotated. Each of the sets of cam elements 18 may be formed on a separate member with a plurality of such members assembled into drum 10, but this creates alignment problems. Therefore, it is preferable to form all of the sets of cam elements integrally into the drum 10 by molding or cutting from a suitable plastics material, such as the acetyl resin known as "DELRIN" (Registered Trade Mark).

The cam drum 10 is fixedly attached at one end to a control shaft 20 for rotation therewith as hereafter described. The control shaft 20 extends through a metal bearing 21 in a front bushing 22 and a "C" ring 25 is clipped into an annular notch in the shaft on the opposite side of such bushing from the cam drum to prevent longitudinal movement of such shaft. A rear bearing member 24 fixedly attached to the other end of the cam drum 10 extends into a rear bushing 26. The front and rear bushings 22 and 26 on which the cam drum is rotatably mounted, may be of plastics material and are attached to the printed circuit board by mounting screws 28. A dust cover 30 of aluminum or other suitable metal, is positioned over the cam drum 10 and secured by screws 32 to the front and rear bushings. The bushings 22 and 26 are each provided with three projections 34 and 36, respectively, including two side projections which extend through slots in the opposite sides of the cover 30 and a bottom projection which extends through a hole in the printed circuit board, for additional support and for more accurate spacing of such bushings.

The control shaft 20 is keyed to a rotary detent member 37 fixedly attached to the front end of the cam drum 10 for rotation of such detent member and cam drum by means of a knob 38 attached to the opposite end of such shaft by a set screw 39. As shown in Fig. 4, the detent member 37 is provided with a plurality of detent notches 40 at its outer periphery which engage a spring biased detent roller 42. The detent roller 42 is held by leaf spring 44 extending between spaced shoulders 45 on the front bushing 22 so that such roller engages the detent notches 40 and moves vertically within a slot provided in guide portion 47 of the front bushing. A stop member 46 is provided, having a square opening keyed to a similar shaped shank portion of the detent member 37 for rotation therewith. A stop projection 48 on the stop member engages a stop provided on the front bushing 22 adjacent guide portion 47 to limit rotation of the cam drum 10 to slightly less than 360°.

The printed circuit board 16 is provided with a plurality of conductive strips 50 of copper or other suitable metal provided on the surface of one or both sides of a sheet of plastics insulating material in a conventional manner such as by chemically etching through a photoresist mask. The conductive strips 50 form the conductors of an electrical circuit and may be connected to circuit components 52 such as resistors, capacitors, transistors, etc. which are mounted on the printed circuit board in a conventional fashion with the leads of such components extending through holes provided in the printed circuit board and soldered to portions of the conductive strips surrounding such holes. However, it is also possible that the printed circuit can consist solely of conductive strips 50 without any circuit components 52.

The fixed switch contacts 14 are provided by some of the conductive strips 50 and formed as part of the printed circuit board on one side of such board, as shown in Fig. 5. However, the movable contacts 12 are formed separately from the printed circuit board and later soldered thereto. The movable contacts 12 are made of a suitable metal to provide a resilient leaf spring member, which

is spot welded to a metal mounting pin 54. The mounting pin 54 is inserted through an aperture in the printed circuit board so that the enlarged head of such pin engages such one side of such board and a soldered connection is formed between such pin and a conductive strip 50 on the opposite side of the printed circuit board to fixedly attach the mounting pin 54 and one end of the movable contact 12 to such circuit board.

The movable contact 12 includes a raised cam engaging portion 56 in the form of an inverted "V" intermediate the ends of the contact. A bifurcated contact portion 58 is provided at the free end of the movable contact, which moves into and out of engagement with the fixed contact 14 when the cam element 18 engages and disengages portion 56. The bifurcated contact portion 58 extends in an arc downward from an intermediate portion 60 which extends between portions 56 and 58 substantially coplanar with the fixed end of the movable contact in its unflexed condition. When the cam drum 10 rotates to cause a cam element 18 to engage the raised portion 56 of the movable contact 12, such contact is pivoted downward into position 12', causing the bifurcated end portion 58 of such movable contact to engage the fixed contact 14, as shown in Figs. 3 and 5.

Another embodiment of the switch apparatus of the present invention includes a two position slide switch having a sliding cam actuator which is shown in Figs. 6 to 8. A printed circuit board having movable and fixed switch contacts mounted thereon similar to that previously described is also used in this second embodiment and for this reason the same reference numerals have been used as in Figs. 1 to 5 to indicate these elements in Figs. 6 to 8 without any further description thereof. A sliding cam member 62 having four laterally spaced cam portions 64 provided on the bottom thereof is attached to a control shaft 66 by a coupling member 68. The coupling member 68 may be in the form of a plastics sleeve having a pair of spaced end flanges between which the U-shaped end of actuator arm portion 70 of the cam member 62 is positioned. The coupling member 68 is fixedly secured to the control shaft 66 by a set screw 72 so that longitudinal movement of the cam actuator arm 70, as indicated by direction arrows 76, between the position shown in solid lines to the position 70' shown in phantom lines. This causes the cam portions 64 to slide across the surface of their movable contacts 12 and engage their raised portion to move such contacts downward into engagement with the fixed contacts 14. As shown in Fig. 8, the cam portions 64 are longitudinally displaced from one another so that two of the cam portions urge their corresponding movable contacts into engagement with the fixed contacts in one switch position of the cam member 62, while the two other cam portions urge their movable contacts into engagement with the fixed contacts in the other switch position.

A guide member 78 for guiding the movement of the cam member 62 is attached to the circuit board 16 and provided with a slot 80 in its upper surface of sufficient length to enable movement of the cam actuator arm 70 within such slot between the two switch positions. The guide member 78 is provided with a guideway 82 in which the cam member 62 slides longitudinally with the bottom of such guideway engaging the lower surface of the cam member 62 immediately adjacent the opposite sides of the group of four cam portions 64 to space such cam portions the proper distance from the printed circuit board 16. Connector pin portions 84 of deformable plastics material are provided on the bottom of the guide member 78 for insertion through holes in the printed circuit board to attach such guide member to such circuit board. The guide member 78 may be molded of a suitable plastics material, such as acetyl resin known as "DELRIN", while the cam actuator member 62 may be molded of a somewhat harder plastics material, such as a glass particle filled nylon.

It will be obvious to those having ordinary skill in the art that many changes may be made in the above-described details of the preferred embodiment of the present invention without departing from the invention. For example, other cam actuators may be employed, such as push-button actuators including those which move perpendicular to the printed circuit board.

WHAT WE CLAIM IS:—

1. Switch apparatus, comprising: printed circuit board means including a support member of insulating material having a plurality of spaced, insulated conductive regions thereon forming portions of an electrical circuit; switch means for changing the connections of said circuit portions, including a plurality of pairs of switch contacts connected to at least some of said conductive regions with the movable switch contacts of said switch means being fixedly attached to said support member of said circuit board means; and cam actuator means including a cam member having a plurality of separate cam portions thereon for selectively moving said movable contacts with said cam portions to open and close the pairs of switch contacts, said cam actuator means being mounted on the same side of the circuit board as the switch contacts to provide a unitary switch apparatus.

2. Switch apparatus in accordance with claim 1, in which the pairs of contacts include stationary contacts mounted directly on said support member and the movable contacts are spring members.

3. Switch apparatus in accordance with claim 2, in which the circuit board means in-

cludes a sheet of insulating material and a layer of conducting material provided on said sheet from which the separate insulated conductive regions are formed, and the stationary contacts of the switch means are formed by some of said conductive regions.

4. Switch apparatus in accordance with claim 3, in which the circuit board means has electrical circuit components including resistors mounted thereon and the switch contacts are connected to conductive regions at least some of which are connected to said components.

5. Switch apparatus in accordance with claim 1, in which the cam actuator means includes a control shaft and a rotary cam member mounted on said control shaft for rotation therewith and including a plurality of cam elements positioned to engage different ones of said movable contacts.

6. Switch apparatus in accordance with claim 5, in which the rotary cam member is a cam drum of plastics material having said cam elements formed integral with said drum.

7. Switch apparatus in accordance with claim 1, in which the cam acuator means includes a sliding cam member having a plurality of cam elements provided on said cam member in position to engage different ones of said movable contacts.

8. Switch apparatus in accordance with claim 2, in which the movable contacts each have at least one freely movable contact end divided into a plurality of contact fingers and a fixed portion attached to a mounting pin secured in a hole provided through said support member.

9. Switch apparatus in accordance with claim 5 which also includes detent means comprising a notched detent member attached to said control shaft for rotation therewith and a spring biased detent roller mounted adjacent said control shaft to engage the detent notches on said detent member for determining the positions of the cam elements corresponding to the different switch positions.

10. Switch apparatus substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 5

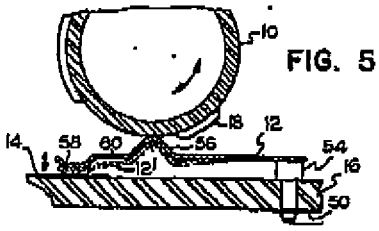


FIG. 2

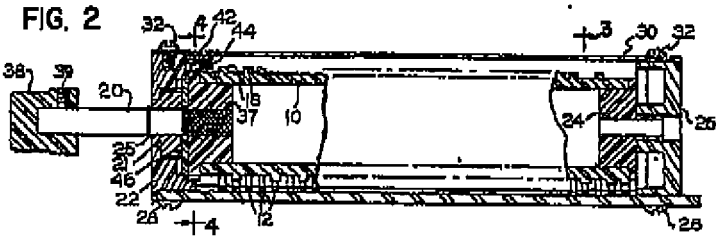


FIG. 1

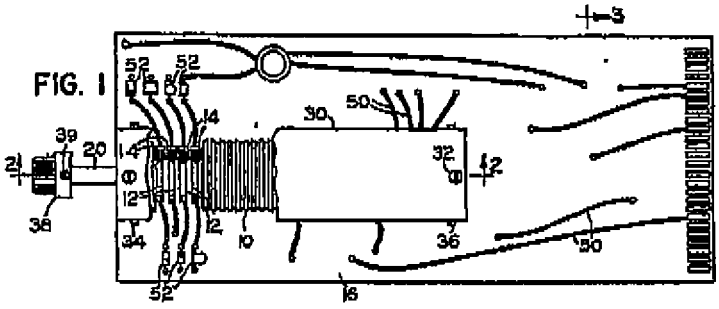


FIG. 4

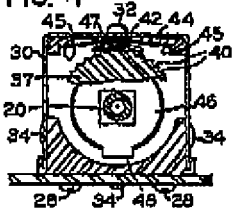
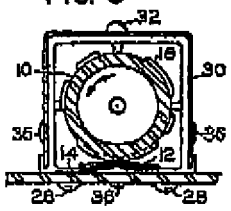


FIG. 3



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Sheet 2

FIG. 6

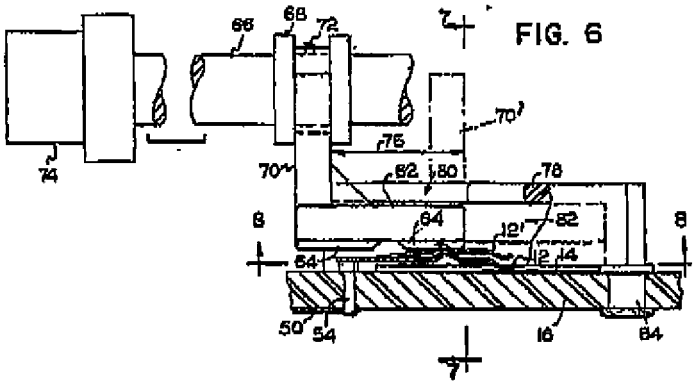

FIG. 7

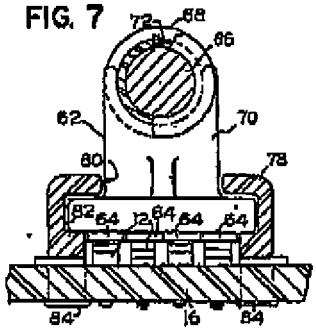

FIG. 8